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(71) Applicant(s)
Moulinex S.A.
(Incorporated in France)
2 Rue de L'Industrie, F-14123 Cormelles le Royal, France

(72) Inventor(s)
Jacques Imbeaud
Joseph Letorey

(74) Agent and/or Address for Service
Page White & Farrer
54 Doughty Street, LONDON, WC1N 2LS, United Kingdom

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GB 2109944 A EP 0380369 A1 US 5437002 A
US 5367146 A

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(54) Abstract Title
Method of controlling a heating element of an electric device for heating a liquid

(57) An electrical device for heating a liquid, e.g. a kettle or a fat fryer, comprises a heating resistor and an associated thermistor. The control method comprises enabling the supply to the heating resistor for a first period (T1), then cutting the supply for a second period (T2). The temperature variation seen by the thermistor is monitored between the beginning of the first period and the end of the second period (tf). The supply is disabled only if the variation exceeds a predetermined threshold value. This allows the thermistor time to react to the initial period of heating and allows the supply to be cut if a fast temperature rise is detected before the heating element is damaged.

After this initial test phase a heating phase (PC) may occur consisting of a series of elementary time intervals (Pci) where the heating element is energised and the temperature seen by the thermistor is checked at the end of each such interval until a predetermined set point is reached. The heating element may be a screen printed heating resistor.

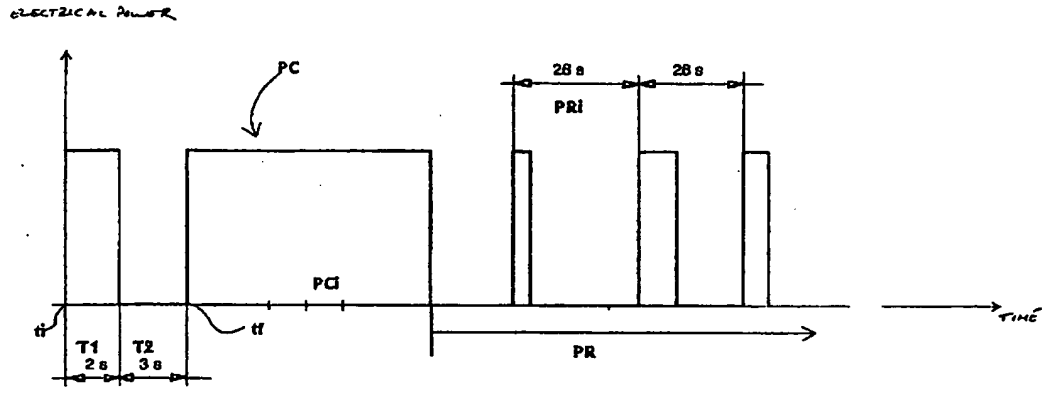

Fig. 2

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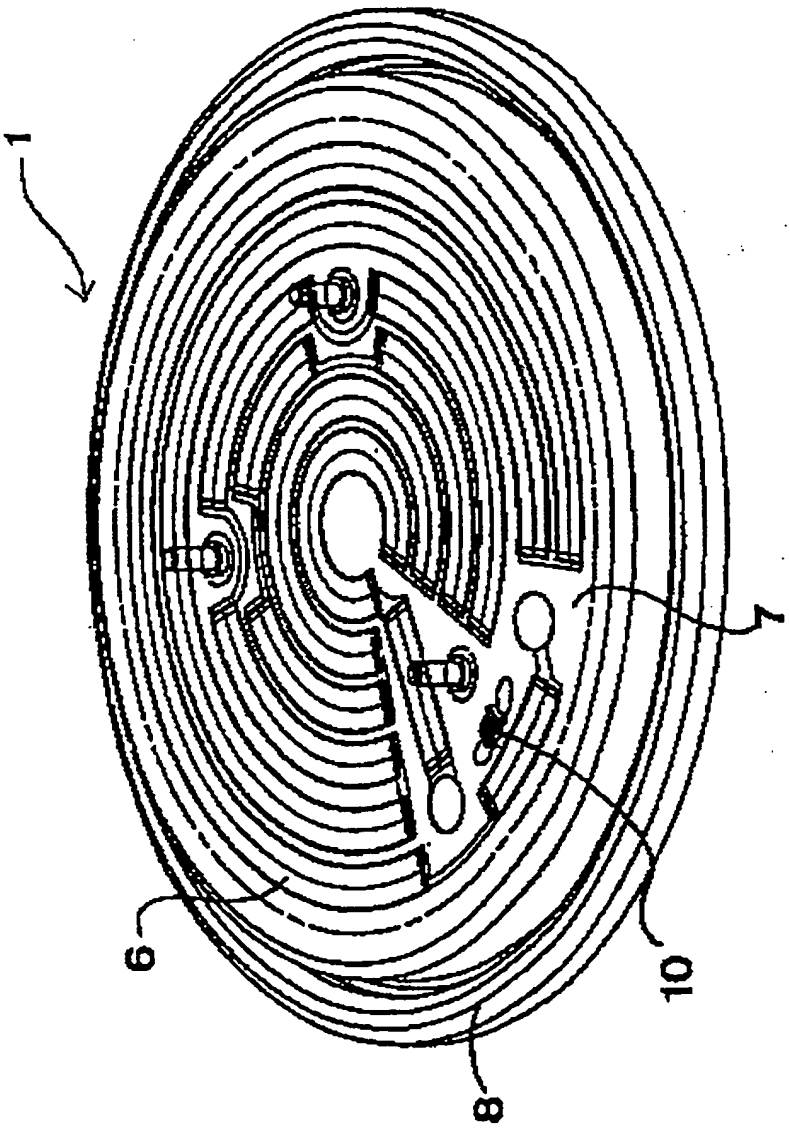

Fig. 1

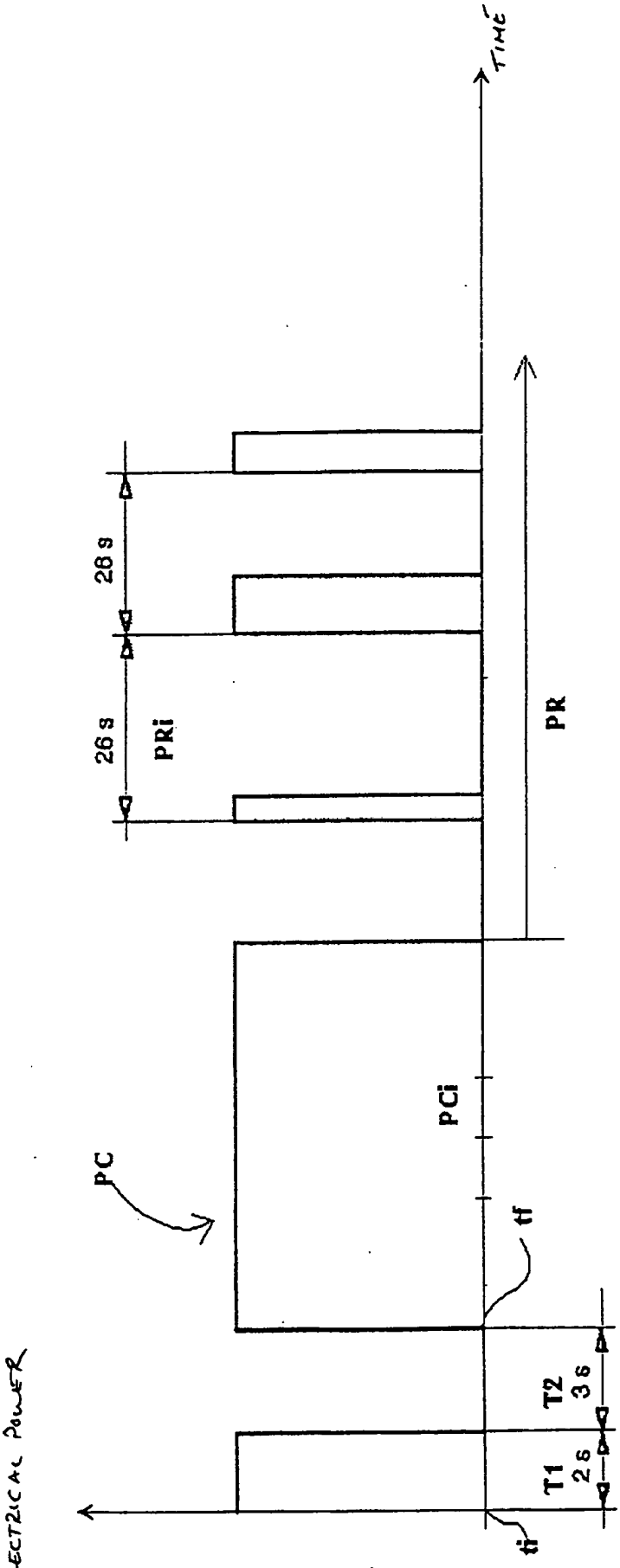

Fig. 2

METHOD OF CONTROLLING A HEATING ELEMENT OF AN ELECTRICAL DEVICE FOR HEATING LIQUID

The invention relates to the field of domestic electrical appliances, and more precisely to electrical devices for heating liquid comprising a heating element of the electrical resistor type.

The invention is, particular, intended for devices such as kettles or electric fryers, or for the water-heating container of electric coffeemakers.

The invention concerns, in particular, a method of controlling the supply to an electrical heating resistor of a device for heating liquid, a thermistor being fixed in proximity to the said electrical resistor so that the resistance value of the thermistor constitutes an image of the temperature of the electrical resistor.

A device of the type to which the invention is ideally applied has previously been described in the French Patent Application FR-99.03999.

As they are generally designed at present, electrical devices for heating liquid, more particularly kettles, are equipped with mechanical safety systems which cut the supply of electricity to the heating element beyond a certain temperature threshold of the said heating element, and which consist, for example, of bimetallic circuit breakers and thermal steam detectors capable of interrupting the heating of the liquid.

These systems, which operate using a detection and actuation method based only on the exceeding of a temperature threshold, are not entirely satisfactory, firstly because, when it is added to that of the heating element, the thermal inertia of the detectors leads to delayed cut-out of the supply in the event of aberrant operation, the consequence of which is to

increase the risks of prematurely damaging the heating element, and all the more so if the heating element operates at high power; secondly because the cut-out threshold is dictated by the nature of the detectors, and is not therefore changeable. For example, the use of a kettle at altitude is rendered problematic since the detectors are not suited to a boiling temperature lower than under the most common working conditions.

The principal object of the invention is to provide a way of actuating the supply to the heating element which makes it possible to guarantee rapid cut-out in the event of aberrant operating conditions, that is to say operating without any liquid, with an insufficient quantity of liquid, or in the event of excessive tilting of the device which causes a part of the heating element to be operated without any liquid, or in the event of significant scaling of the heating element.

This object is achieved by the invention, according to which the control method includes an initial test phase consisting in successively:

a) enabling the supply of electricity to the heating resistor during a first time interval when turning the device on, which is taken as the initial state;

b) cutting the supply during a second time interval;

c) monitoring the temperature variation seen by the thermistor between the initial state and the state at the end of the second interval;

d) disabling the supply if this temperature variation exceeds a first predetermined threshold value;

e) enabling the supply in the converse case.

By virtue of this arrangement, any excessively fast temperature rise of the heating element is detected and is interpreted in such a way as to deliver a cut-out signal, the detection taking place upon completion of a cut-out phase, by using the thermal

inertia of the heating element, and hence without any risk of damaging the heating element if the duration of the first time interval is chosen to be small enough.

Other characteristics and advantages of the invention will become apparent from the following description, which is given by way of non-limiting example with reference to the appended drawings, in which:

- Figure 1 is a perspective view of a heating element to which the invention can be applied;

- Figure 2 is a graph representing a supply sequence using the method to which the invention relates.

Figure 1 represents the heating element 1 of an electric kettle, consisting of a screen-printed resistor 6 having at least one resistive track formed on an electrically insulating plate 7 which is a good conductor of heat. The insulating plate 7 is secured to a metal support 8, preferably made of stainless steel, and constitutes the bottom of the container of the kettle, so that the insulating plate 7 and the support 8 are in thermal contact and the resistive track 6 is electrically insulated from the metal support 8.

A thermistor 10, for example a negative temperature coefficient resistor, also called "NTC" resistor, is fixed on the insulating plate 7 in proximity to the electrical resistor formed by the resistive track 6; its resistance varies as a function of the temperature variations of the resistive track 6 and of the insulating plate 7; the value of its resistance hence constitutes an image of the temperature of the electrical resistor 6.

According to the invention, the supply of electricity to the heating resistor 6 is controlled using a method which includes an initial test phase consisting in successively:

a) enabling the supply of electricity to the heating resistor 6 during a first time interval T1 when turning the device on, which is taken as the initial state ti;

b) cutting the supply during a second time interval T2;

c) monitoring the temperature variation seen by the thermistor between the initial state and the state at the end of the second interval tf;

d) disabling the supply if this temperature variation exceeds a first predetermined threshold value;

e) enabling the supply in the converse case.

The supply circuit of the heating resistor 6 is cut, for example, by a switch actuated by a micro-controller which produces its actuation signals on the basis of the state, or the successive states, of the thermistor 10 and of pre-recorded threshold values.

It is easy to see that an excessively rapid increase of the temperature picked up by the thermistor 10 signifies either that the heating element 1 is operating partially or completely without liquid, or that it has become scaled, with a layer of limescale deposited on the heating element 1 creating relatively significant thermal insulation of the said heating element.

Such a state is picked up extremely reliably and rapidly after a heating time T1 and a cut-out time T2 which are very short, and this saves the heating element 1 from operating under conditions which constitute the main causes for its premature wear.

As an example, the first time interval T1, the supply time interval, may be selected with a duration of between 1.5 and 3 seconds, this duration being particularly suited to a screen-printed track operating at a power of from 2 to 3 kilowatts.

For its part, the second time interval T2 preferably has a duration of between 2.5 and 4 seconds.

According to a first embodiment of the invention, following the test phase, if the supply is enabled upon completion of the second time interval T2, the method of controlling the supply to the heating resistor 6 includes a heating phase PC consisting of a series of elementary time intervals PCi, during which series the heating resistor 6 is supplied with electricity, the temperature seen by the thermistor 10 being observed at the end of each elementary interval PCi, so that the supply is cut as soon as the temperature exceeds a predetermined setpoint value.

The object of this first embodiment is to produce a liquid-heating cycle PC which is interrupted when the liquid reaches a temperature defined, for example, by a setpoint which is set by the user and is lower than the boiling temperature of the liquid; or by a heating programme corresponding to a particular cooking mode, with the possibility of providing several successive heating cycles.

Alternatively, according to a second embodiment, following the test phase, if the supply is enabled upon completion of the second time interval T2, the control method includes a heating phase PC consisting of a series of elementary time intervals PCi, during which series the heating resistor 6 is supplied with electricity, the temperature seen by the thermistor 10 being observed at the end of each elementary interval PCi, so that the supply is cut as soon as the temperature variation over an elementary time interval PCi is less than a second predetermined threshold value.

In the latter embodiment, the condition for cutting the supply is determined by an inflection of the temperature curve, which is interpreted as the approaching of a plateau on this temperature curve; in the most common case, such a plateau signifies boiling

of the liquid, but in exceptional cases it may signify malfunction of the heating element or of its supply circuit. It is possible to discriminate between these two cases with almost complete certainty by observing the temperature level. Simultaneously with the signal which cuts the supply to the heating element, a warning signal may be emitted if the temperature profile describes a plateau even though the temperature lies below a predetermined level, for example 90°C.

It will be understood that the cut-out condition does not depend only on the temperature level reached, and this makes it possible, in the case of an electric kettle, to render the use of the device independent of external pressure conditions which, as has already been mentioned with regard to current devices, are problematic in the event of use at altitude.

In both embodiments, the elementary time interval PCi advantageously has a duration of the order of a few seconds, and more precisely between 4 and 6 seconds.

According to the invention, following the heating phase PC, the control method furthermore includes a regulating phase PR consisting in successively:

a) upon completion of a first predetermined period after the time at which the supply is cut at the end of the heating phase, observing the temperature seen by the thermistor 10;

b) enabling the supply to the electrical resistor 6 during a time interval which is shorter than a second predetermined period Pri and depends on the temperature observed; this time interval is also dependent on a pre-adjusted setpoint temperature value;

c) observing once more the temperature seen by the thermistor 10;

d) repeating the successive stages b) and c) cyclically until a stopping setpoint is reached.

It is beneficial, once the liquid has been brought to the temperature which the user desires, to heat the liquid again periodically in order to keep it hot, and do so until a stop instruction which is given, for example, purely and simply by the user stopping the device, or by a time limit being reached. The liquid is hence kept hot by means of low energy consumption and without special supervision of the device.

The heating cycles of the regulating phase are repeated with a periodicity which must be compatible with the standards in force for protecting electrical networks, that is to say the second period Pri is selected to be of the order of 25 to 30 seconds for a resistor operating at a power of the order of 2 kilowatts.

The invention makes it possible both to increase the operating safety of domestic electrical appliances for heating liquid, and also to make them easier to use, by arrangements which can be implemented very economically, in particular simply by programming a micro-controller.

PATENT CLAIMS

1. Method of controlling the supply to an electrical heating resistor (6) of a device for heating liquid, a thermistor (10) being fixed in proximity to the said electrical resistor (6) so that the resistance value of the thermistor (10) constitutes an image of the temperature of the electrical resistor (6), characterised in that it includes an initial test phase consisting in successively:

a) enabling the supply of electricity to the heating resistor (6) during a first time interval (T1) when turning the device on, which is taken as the initial state (ti);

b) cutting the supply during a second time interval (T2);

c) monitoring the temperature variation seen by the thermistor between the initial state and the state at the end of the second interval (tf);

d) disabling the supply if this temperature variation exceeds a first predetermined threshold value;

e) enabling the supply in the converse case.

2. Control method according to Claim 1, characterised in that following the test phase, if the supply is enabled upon completion of the second time interval (T2), it includes a heating phase (PC) consisting of a series of elementary time intervals (Pci), during which series the heating resistor (6) is supplied with electricity, the temperature seen by the thermistor (10) being observed at the end of each elementary interval (Pci), so that the supply is cut as soon as the temperature exceeds a predetermined setpoint value.

3. Control method according to Claim 1, characterised in that following the test phase, if the

supply is enabled upon completion of the second time interval (T2), it includes a heating phase (PC) consisting of a series of elementary time intervals (Pci), during which series the heating resistor (6) is supplied with electricity, the temperature seen by the thermistor (10) being observed at the end of each elementary interval (Pci), so that the supply is cut as soon as the temperature variation over an elementary time interval (Pci) is less than a second predetermined threshold value.

4. Control method according to Claim 2 or 3, characterised in that following the heating phase, it includes a regulating phase consisting in successively:

a) upon completion of a first predetermined period after the time at which the supply is cut at the end of the heating phase, observing the temperature seen by the thermistor (10);

b) enabling the supply to the electrical resistor (6) during a time interval which is shorter than a second predetermined period (Pri) and depends on the temperature observed;

c) observing once more the temperature seen by the thermistor (10);

d) repeating the successive stages b) and c) cyclically until a stopping setpoint is reached.

5. Control method according to any one of Claims 1 to 4, characterised in that the first time interval (T1) has a duration of between 1.5 and 3 seconds.

6. Control method according to any one of Claims 1 to 5, characterised in that the second time interval (T2) has a duration of between 2.5 and 4 seconds.

7. Control method according to Claim 2, characterised in that the elementary time intervals (Pci) have a constant duration of between 4 and 6 seconds.

8. Device for heating liquid, comprising a screen-printed heating resistor, the supply to which is controlled using the method according to any one of Claims 1 to 7.

9. Electric kettle comprising a heating resistor, the supply to which is controlled using the method according to any one of Claims 1 to 7.

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Claims searched: All

Examiner: Rowland Hunt
Date of search: 29 September 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H2H (HHR1, HHR6, HHR7)

Int Cl (Ed.7): A47J 27/62, 27/21; G05D 23/19; H05B 1/02;

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2109944 A	(SHARP)	
A	EP 0380369 A1	(OTTER CONTROLS)	
A	US 5437002	(PARAGON)	
X	US 5367146	(ZEHNDER) see particularly col. 3, lines 25-37 and fig. 2.	1, 2 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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